Biological Psychology 121 (2016) 138–145

Contents lists available at ScienceDirect

Biological Psychology

journal homepage: www.elsevier.com/locate/biopsycho

Itsy bitsy spider? Valence and self-relevance predict size estimation

Tali Leibovich[a,c,*,1], Noga Cohen[b,1], Avishai Henik[b]

[a] Department of Cognitive Sciences and the Zlotowski Center for Neuroscience, Ben-Gurion University of the Negev, Israel
[b] Department of Psychology and the Zlotowski Center for Neuroscience, Ben-Gurion University of the Negev, Israel
[c] Department of Psychology and the Brain and Mind Institute, the University of Western Ontario, London, Canada

ARTICLE INFO

Article history:
Received 30 June 2015
Received in revised form 18 January 2016
Accepted 18 January 2016
Available online 21 January 2016

Keywords:
Size estimation
Individual differences
Phobia
Spiders
Self-relevance

ABSTRACT

The current study explored the role of valence and self-relevance in size estimation of neutral and aversive animals. In Experiment 1, participants who were highly fearful of spiders and participants with low fear of spiders rated the size and unpleasantness of spiders and other neutral animals (birds and butterflies). We found that although individuals with both high and low fear of spiders rated spiders as highly unpleasant, only the highly fearful participants rated spiders as larger than butterflies. Experiment 2 included additional pictures of wasps (not self-relevant, but unpleasant) and beetles. The results of this experiment replicated those of Experiment 1 and showed a similar bias in size estimation for beetles, but not for wasps. Mediation analysis revealed that in the high-fear group both relevance and valence influenced perceived size, whereas in the low-fear group only valence affected perceived size. These findings suggest that the effect of highly relevant stimuli on size perception is both direct and mediated by valence.

1. Introduction

Imagine that while reading these lines, a spider crawls on your desk. You might refer to it as small and harmless, while your spider-phobic co-worker would probably perceive it as huge and intimidating. These kinds of situations highlight the existence of individual differences in size estimation of unpleasant stimuli. They also raise the question of whether the pair of words “huge” and “intimidating” represents more than a figure of speech. Namely, is size perception modulated by the emotional value of the stimulus? The current study explored this question by examining the effects of stimulus valence and relevance on size estimation among individuals who were afraid of spiders, relative to individuals with low fear of spiders.

Several studies indicate that negative stimuli are perceived as larger compared to neutral and positive stimuli (Teachman, Stefanucci, Clerkin, Cody, & Proffitt, 2008; van Ulzen, Semin, Oudejans, & Beek, 2008; Whitehouse, Freeman, & Annandale, 1988). van Ulzen et al. (2008) presented circles containing a positive (dollar sign), negative (swastika) or a neutral (black square) image, and asked participants to reproduce the size of the circles (i.e., perceptual size matching). While participants underestimated all the circles compared to their actual size, circles with negative images were significantly less underestimated than circles containing neutral or positive images. These findings imply that negative stimuli are perceived as larger than neutral and positive stimuli. Additional evidence for bias in size estimation comes from studies that used clinical or sub-clinical populations. Whitehouse, Freedman, and Annandale (1986) found that women suffering from bulimia overestimated their own body size (as seen on a television screen) compared to estimating the body size of a dummy. Participants suffering from acrophobia stood on a balcony and were asked to estimate the size of a disk on the ground. Acrophobic participants estimated the size of the disk to be smaller than control participants did. Hence, the authors suggested that acrophobics overestimated the height of the balcony (Teachman et al., 2008; see also Clerkin, Cody, Stefanucci, Proffitt, & Teachman, 2009). Vasey, Vilensky, Heath, Harbaugh, and Buffington (2012) found a positive correlation between size estimation of spiders and levels of fear among spider-phobic individuals. Note, however, that while in the aforementioned studies size perception was examined while participants viewed the to-be-estimated object (Teachman et al., 2008; van Ulzen et al., 2008; Whitehouse et al., 1986), Vasey et al. (2012) covered the spider before the size assessment, thus making

* Corresponding author at: Department of Cognitive Sciences, Ben-Gurion University of the Negev, P.O.B. 653, Beer-Sheva 84105, Israel. Fax: +972 8 6433073.
E-mail address: labovich@post.bgu.ac.il (T. Leibovich).
[1] Equal contribution.

http://dx.doi.org/10.1016/j.biopsycho.2016.01.009

the size estimation memory dependent. Rachman and Cuk (1992) failed to find bias in size estimation among spider-fearful individuals (although other perceptual distortions were observed; see also Riskind, Moore, & Bowley, 1995). Importantly, in addition to bias in size estimation, emotional stimuli were found to be associated with expectancy bias (for a review see Aue & Okon-Singer, 2015; Mühlberger, Wiedemann, Herrmann, & Pauli, 2006), attentional biases (for a meta-analysis see Bar-Haim & Lamy, 2007; for review see Okon-Singer, Lichtenstein-Vidne, & Cohen, 2013), and various perceptual distortions (Rachman & Cuk, 1992).

It is noteworthy that except for van Ulzen et al.'s (2008) study, the evidence for bias in size estimation (as well as other cognitive biases) for unpleasant stimuli comes from studies that used specific populations that considered the stimulus as highly relevant; a spider presented to spider-phobic individuals (Mühlberger et al., 2006; Vasey et al., 2012), wrist size to anorexic patients (Whitehouse et al., 1988), and height estimation to individuals who were afraid of heights (Stefanucci, Gagnon, & Lessard, 2011). Therefore, the stimuli that were associated with perceptual or cognitive bias in these studies were not only negatively valenced, but were also self-relevant for the specific individuals chosen to take part in these studies. Namely, individuals with specific phobias (e.g., spider-phobia, fear of heights) or obsessions (e.g., body weight for anorectic patients) are occupied by stimuli related to their phobias/obsessions on a daily basis. Thus, bias in size estimation in these studies may have resulted from two possible factors—stimulus valence and its self-relevance to the participant. In the current work we define a self-relevant stimulus as a stimulus that is personally significant due to its relevance to the individual's concerns, occupation, or values (Bruner & Postman, 1948). Self-relevant stimuli are present in the individual's thoughts and actions on a daily basis, and are associated with either positive or negative value (e.g., food for an anorectic patient, drug for an addict, a character from a TV show for a dedicated fan).

Not only negative, but also positive self-relevant stimuli were found to be associated with perceptual and cognitive biases. For example, Bruner and Goodman (1947) showed that children from a low socio-economic status, but not children from high socio-economic status, overestimated the size of a coin compared to the size of a circle. Assuming that the coins were perceived as positive stimuli for the low socio-economic children, these results support the notion that the relevance of a stimulus to everyday life, and not its mere valence, alters size perception. Additional evidence comes from a study that showed that individuals who are afraid of spiders have an attentional bias toward pictures of spiders and similarly, individuals who are fans of the series "Doctor Who" have an attentional bias toward pictures of characters from the TV show (Purkis, Lester, & Field, 2011). The third evidence comes from addiction studies showing cognitive biases to stimuli depicting drug-related items (e.g., attentional bias among cocaine users: Hester, Dixon, & Garavan, 2006; attentional and approach biases among smokers: Mogg, Field, & Bradley, 2005; approach bias among alcoholics: Wiers, Rinck, Dictus, & van den Wildenberg, 2009).

Taken together, the bias in size estimation reported in previous studies may be explained both by the relevance of the unpleasant object to the participants and by its aversive value. Moreover, most studies thus far assessed the perceptual size of an object, and it is unknown whether the mental representation of self-relevant unpleasant stimuli is also subjected to bias in size estimation. Furthermore, it is unclear whether individuals who have a specific phobia or psychological disorder would show a bias in size estimation only for the disorder-related stimuli or also for other, disorder-unrelated, unpleasant stimuli.

The current study includes two experiments. Experiment 1 was designed to explore whether self-relevance modulates bias in size estimation for the mental representation of unpleasant stimuli. Specifically, we asked whether individuals who consider spiders to be highly self-relevant, according to the fear of spiders questionnaire (Klorman, Weerts, Hastings, Melamed, & Lang, 1974; Okon-Singer, Alyagon, Kofman, Tzelgov, & Henik, 2011), would imagine them as larger than individuals who do not consider spiders as self-relevant. With that aim in mind, individuals with high fear of spiders and individuals with low fear of spiders rated the size and unpleasantness of spiders, birds and butterflies. In order to evoke mental representations, pictures of the animals were presented and participants were asked to rate the size of these animals in reality relative to the size of a fly or a lamb.

As discussed above, self-relevance and/or stimulus valence can alter size perception (e.g., Stefanucci et al., 2011; Whitehouse et al., 1988). In addition, spider-phobic individuals show attentional and expectancy biases toward spiders (Aue, Guex, Chauvigné, & Okon-Singer, 2013; Aue, Hoeppli, Piguet, Sterpenich, & Vuilleumier, 2013; Davey & Dixon, 1996; de Jong & Muris, 2002; Mühlberger et al., 2006; Riskind et al., 1995; Teachman & Woody, 2003). Based on such evidence, we predicted that individuals who are highly afraid of spiders (from here on—highly fearful individuals, or high-fear group) would show a larger bias in size estimation of spiders compared to low-fear individuals (i.e., low-fear group). Specifically, we expected that spiders would be rated as larger than neutral animals similar to spiders in size (i.e., butterflies), especially among individuals in the high-fear group.

Experiment 2 was designed to explore whether a bias in size estimation also occurs for unpleasant stimuli that are not self-relevant. Specifically, we asked whether the size of an unpleasant but irrelevant stimulus would be distorted. Experiment 2 included pictures of wasps (unpleasant but irrelevant stimuli), in addition to pictures of butterflies and spiders. If size bias is specific to self-relevant objects, we would expect to find no difference between the size estimation of wasps in both groups.

2. Experiment 1

2.1. Method

2.1.1. Participants

Twenty-seven students (all females—13 in the high-fear group and 14 in the low-fear group) at Ben-Gurion University of the Negev participated in the experiment for course credit. We chose only female participants due to the higher probability of women to suffer from spider-phobia compared to men and in order to avoid potential gender effects (Okon-Singer et al., 2011). All participants had intact or corrected-to-normal vision. Data from two participants was excluded because of deviant unpleasantness ratings (more than 2 SD above the mean unpleasantness rating of their group). Hence, the total sample included 12 participants in the high-fear group (mean age = 22.9 years, SD = .95) and 13 participants in the low-fear group (mean age = 23 years, SD = .93).

2.1.2. Stimuli

The target stimuli included pictures of spiders, butterflies and birds (7 different pictures of each; see Fig. 1A). All the pictures appeared in the same physical size (250×250 pixels). A trial included a line (visual analog scale, or VAS) flanked by a picture of a fly to the left and a picture of a lamb to the right. These pictures served as reference points for the target picture's size estimation. A target picture appeared below the VAS. The size and location of the VAS, the cursor, and the location of the target picture varied randomly in order to encourage participants to rethink their mapping in every trial, and not to rely on previously mapped locations (Wewers & Lowe, 1990).

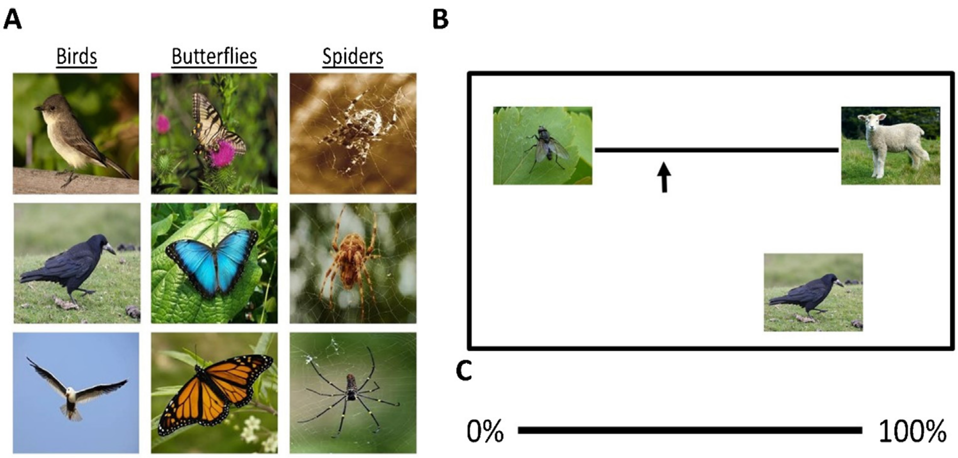

Fig. 1. Stimuli and procedure—Experiment 1. (A) Stimuli pictures—all stimuli were presented in the same physical size of 228 × 197 pixels. (B) An example of a typical trial. The same pictures of a fly and lamb appeared in every trial with the stimulus to-be-rated appearing in a random position underneath. (C) Visual analog scale (VAS): the left side of the line equals 0%, representing small conceptual size (closer to a fly) or low unpleasantness rating; the right side of the line equals 100%, representing large conceptual size (closer to a lamb) or high unpleasantness. Note, the pictures presented here are for illustration purposes. Pictures of spiders were taken from the IAPS (International Affective Picture System; Lang, Bradley, & Cuthbert, 2008) while pictures of the other animals were taken from "google images". These pictures were labeled for reuse under "usage rights".

2.1.3. Procedure

2.1.3.1. Screening. A questionnaire regarding fear of spiders (Klorman et al., 1974), already translated to Hebrew, taken from Okon-Singer et al. (2011), was distributed online and completed by students. In addition to the original questionnaire, we also included one question regarding fear of each of the other animals included in the experiment (i.e., flies, butterflies, birds and lambs) for screening purposes. The score in the fear-of-spiders questionnaire ranged from 0 to 31, with higher scores indicating greater fear of spiders. Based on the scores of the first 80 students who filled the questionnaire, we set the top 20% (i.e., a score over 11) as high fear and the bottom 20% (i.e., score less than 6) as low fear. Thus, students who scored over 11 or under 6, and did not report fear of the other animals presented in the experiment, were invited to participate in the experiment.

2.1.3.2. Experimental task. The experimental task included two parts. In the first part, participants were requested to rate the hypothesized real-world size of target pictures ranging from a fly to a lamb. Each trial began with a blank screen for 200 ms, followed by a VAS flanked by pictures of a fly and a lamb. The location of the picture on the VAS indicated size estimations in percentages; the left side (fly picture) indicated a size of 0% (i.e., the size of a fly); the right side (lamb picture) indicated a size of 100% (i.e., the size of a lamb). Participants rated the size of target pictures (spider, butterfly or bird) that appeared under the VAS by indicating a location with the mouse cursor on the VAS (see Fig. 1C and B). The initial location of the cursor on the line varied randomly. The VAS and pictures remained on the screen until the participant responded but not for longer than 8 s. After 150 ms of a blank screen, a new trial began. Six practice trials (with pictures of other animals) were followed by 4 blocks of 21 trials each [3 conditions (spider, butterfly, bird) × 7 pictures]. In the second part of the experiment, participants were asked to rank on a VAS how unpleasant each picture made them feel. For that purpose, the VAS was flanked with the words "not at all" to the left and "very unpleasant" to the right. Each picture was rated once.

2.2. Results

In order to verify that the questionnaire accurately differentiated between the high-fear and the low-fear groups, we examined whether these two groups differed in the unpleasantness ratings of the target pictures. Mean unpleasantness values were subjected to a two-way mixed-measure analysis of variance (ANOVA) with group (high-fear, low-fear) as a between-subject variable and condition (spiders, birds and butterflies) as a within-subject variable. We calculated the Bayes factor (BF) for every main effect and interaction. Bayes factors express the ratio between the evidence in favor of the hypothesis relative to the null hypothesis. Bayes factors with a value around 1 indicate that the analysis is not sensitive enough and more data should be collected. Bayes factors over 3 suggest that the analysis is sensitive enough in order to accept the experimental hypothesis (Dienes, 2008). Bayes factors were calculated using JASP—a free software for statistical analysis (https://jasp-stats.org). The Bayes factor of the main effect for group, for example, was $1e^{17}$. Namely, this estimated BF (hypothesis/null) suggested that the data were $1e^{17}$ more likely to occur under the model including a main effect of group, rather than the model without it (Jarosz & Wiley, 2014).

Both main effects of group and condition were significant when unpleasantness served as dependent variable $F(1, 23) = 101.98$, $p < .0001$, $\eta^2 p = .82$, $BF = 1e^{17}$ and $F(1, 23) = 167.08$, $p < .0001$, $\eta^2 p = .88$, $BF = 1e^{17}$, respectively. The interaction between group and condition was significant, $F(2, 46) = 73.92$, $p < .0001$, $\eta^2 p = .76$, $BF = 1.8e^{16}$. Planned comparisons revealed that the two groups differed mainly in the unpleasantness ratings of the spider pictures (i.e., high-fear group rated the spiders as more unpleasant than the low-fear group; $F(1,23) = 86.74$, $p < .0001$, $\eta^2 p = .79$, $BF = 2.35e^{6}$). In addition, both the low-fear and the high-fear groups rated the spider pictures as more unpleasant than the other pictures, $F(1, 23) = 9.97$, $p < .005$, $\eta^2 p = .3$, $BF = 4.49e^{10}$ and $F(1, 23) = 227.76$, $p < .0001$, $\eta^2 p = .91$, $BF = 8.43e^{10}$, for birds and butterflies, respectively. The results are illustrated in Fig. 2B.

To examine if the two groups differed in the size estimation of the target pictures, mean size values were subjected to a two-way mixed-measures ANOVA with group (high-fear, low-fear) as a between-subject variable and condition (spiders, birds and butterflies) as a within-subject variable. Both main effects of group and condition were significant when size served as dependent variable $F(1, 23) = 5.7$, $p < .05$, $\eta^2 p = .2$, $BF = 3.9$, and $F(1, 23) = 64.53$, $p < .0001$, $\eta^2 p = .74$, $BF = 3.49e^{12}$, respectively. The interaction between group and condition was marginally significant, $F(2, 46) = 3.07$, $p = .057$, $\eta^2 p = .12$, $BF = 4$. Planned comparisons revealed that the two groups

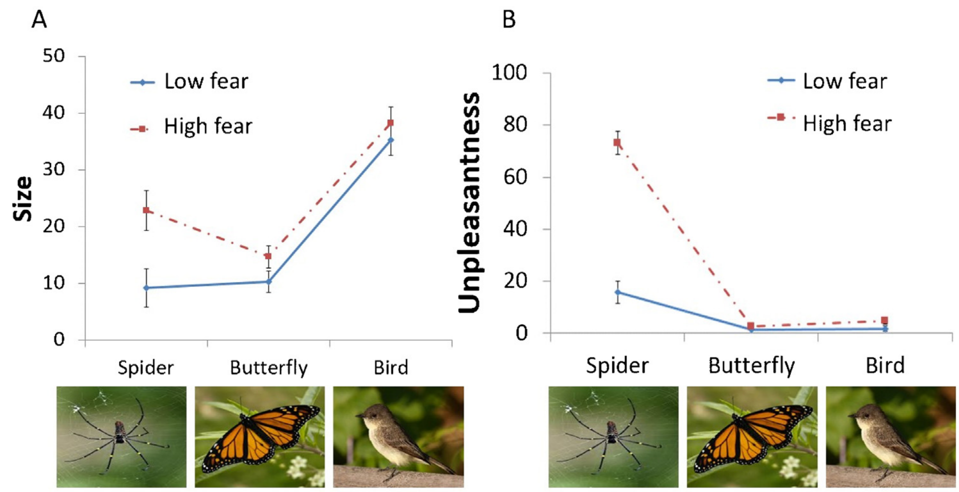

Fig. 2. Results—Experiment 1. (A) Size (0 = the size of a fly, 100 = the size of a lamb), and (B) unpleasantness (0 = "not at all", 100 = "very unpleasant") estimations by group and condition.

did not differ in size estimation of birds and butterflies, $F < 1$, *ns*, and $F(1, 23) = 2.6$, $p = .12$, BF = 0.45; $\eta^2 p = .10$, BF = 0.93, respectively. The high-fear participants, however, rated spiders as larger than the low-fear participants did, $F(1, 23) = 7.71$, $p < .01$, $\eta^2 p = .25$, BF = 4.88. To examine whether both groups showed a bias in size estimation, we compared the ratings of spiders and butterflies in each group. Results demonstrated that the high-fear group rated spiders as significantly larger than butterflies, $F(1, 23) = 7.10$, $p < .05$, $\eta^2 p = 24$, BF = 1.46. In contrast, in the low-fear group there was no difference between the size ratings of spiders and butterflies, $F < 1$, *ns*, BF = 0.547. These results demonstrate that spider pictures were estimated as larger than butterfly pictures only among individuals who are afraid of spiders (Fig. 2A).

3. Experiment 2

Experiment 2 was conducted in order to explore whether bias in size estimation is specific to self-relevant stimuli. Thus, wasps were added as unpleasant stimuli that are not self-relevant. We also added beetles as additional control animals that are similar to spiders in general shape and size.

3.1. Method

3.1.1. Participants

Seventy-four students (all females—44 highly fearful and 30 low-fear participants) at Ben-Gurion University of the Negev participated in the experiment in return for course credit. All participants had intact or corrected-to-normal vision. Data from 10 participants was excluded for the following reasons: technical issues (problems with understanding the task, incomplete task, etc.: 6 participants), deviation in unpleasantness (2 participants) or in size ratings (2 participants) of the stimuli by more than 3 SD above the mean rating of their group. Hence, the total sample included 64 participants; 38 participants in the high-fear group (mean age = 22.74 years, SD = 1.73) and 26 participants in the low-fear group (mean age = 23.35 years, SD = 1.14).

3.1.2. Stimuli

The target stimuli included pictures of spiders, wasps, beetles and butterflies (7 different pictures of each). Pictures of spiders and butterflies were identical to those used in Experiment 1.

3.1.3. Procedure

3.1.3.1. Screening. The fear-of-spiders questionnaire was distributed online among university students. Students who scored over 11 or under 8 in the questionnaire were invited to participate in the experiment. Individuals who participated in Experiment 1 were not allowed to participate in Experiment 2.

3.1.3.2. Experimental task. The experimental task was similar to that of Experiment 1 with two changes. First, the target animals included wasps and beetles in addition to spiders and butterflies and the bird pictures were removed. Second, because we no longer used pictures of birds, the reference picture of the larger size at the right end of the VAS was a picture of a rabbit (Fig. 3).

3.2. Results

Similar to Experiment 1, in order to verify that the questionnaire accurately differentiated between the high-fear and the low-fear groups, we examined whether these two groups differed in the unpleasantness ratings of the target pictures. Mean unpleasantness values were subjected to a two-way mixed-measure ANOVA with group (high-fear, low-fear) as a between-subject variable and condition (spiders, wasps, beetles and butterflies) as a within-subject variable. Both main effects of group and condition were significant when unpleasantness served as dependent variable $F(1, 62) = 43.76$, $p < .0001$, $\eta^2 p = .41$, BF = 1e^{17}, and $F(1, 62) = 83.57$, $p < .0001$, $\eta^2 p = .57$, BF = 1.53e^{12}, respectively. The interaction between group and condition was significant, $F(3, 186) = 15.49$, $p < .0001$, $\eta^2 p = .2$, BF = 1.18e^{7}. Planned comparisons revealed that all the animals except for butterflies were rated as more unpleasant in the high-fear group. However, as suggested by the effect sizes, the difference between the unpleasantness ratings of spiders was the highest; $F(1, 62) = 71.13$, $p < .0001$, $\eta^2 p = .53$, BF = 8.38e^{8}; $F(1, 62) = 18.24$, $p < .0001$, $\eta^2 p = .23$, BF = 309.3; $F(1, 62) = 14.98$, $p < .001$, $\eta^2 p = .19$, BF = 95.69, and $F(1, 62) = 1.4$, $p = .25$, $\eta^2 p = .02$, BF = 0.45, for spiders, beetles, wasps and butterflies, respectively. The results are illustrated in Fig. 4B.

In order to examine whether the two groups differed in the size estimation of the target pictures, mean size values were subjected to a two-way mixed-measures ANOVA with group (high-fear, low-fear) as a between-subject variable and condition (spiders, wasps, beetles and butterflies) as a within-subject variable. Both main effects of group and condition were significant when size served

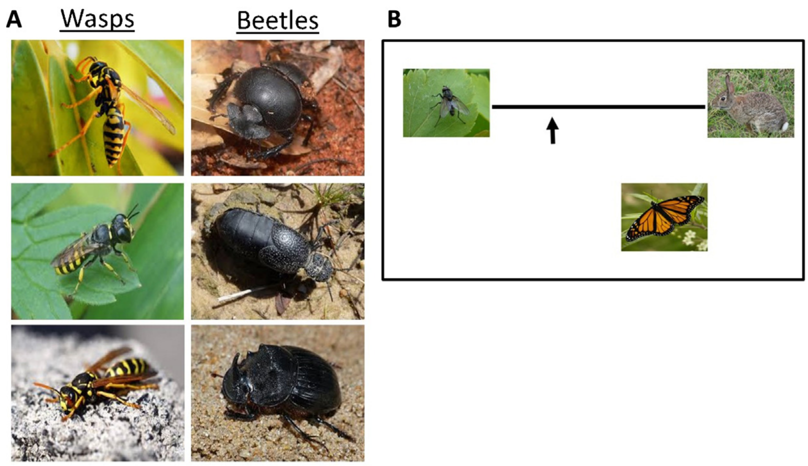

Fig. 3. Stimuli and procedure—Experiment 2. (A) Stimuli pictures included wasps and beetles (depicted here), and also spiders and butterflies from Experiment 1. (B) An example of a typical trial. The same pictures of a fly and a rabbit appeared in every trial with the stimulus to be rated appearing in a random position underneath.

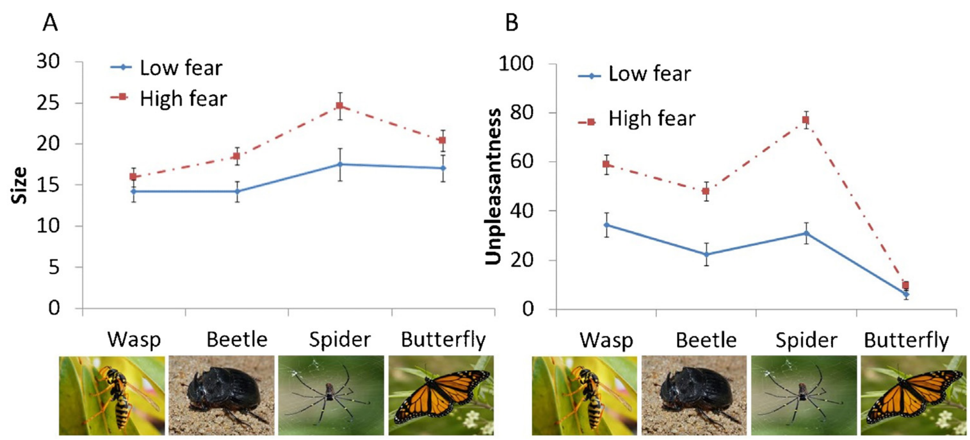

Fig. 4. Results—Experiment 2. (A) Size (0 = the size of a fly, 100 = the size of a rabbit), and (B) unpleasantness (0 = "not at all", 100 = "very unpleasant") estimations by group and condition.

as dependent variable $F(1, 62) = 7.07$, $p < .0001$, $\eta^2p = .1$, BF = 5.05, and $F(1, 62) = 11.91$, $p < .0001$, $\eta^2p = .16$, BF = 3.89e^5, respectively. The interaction between group and condition was marginally significant, $F(3, 186) = 2.18$, $p = .09$, $\eta^2p = .03$, BF = 1.99. Planned comparisons revealed that the two groups did not differ in size estimation of wasps, $F < 1$, BF = 0.38 or butterflies, $F(1, 62) = 2.6$, $p = .11$, $\eta^2p = .04$, BF = 0.76. The highly fearful participants, however, rated both spiders, $F(1, 62) = 7.62$, $p < .001$, $\eta^2p = .11$, BF = 5.86 and beetles, $F(1, 62) = 7.21$, $p < .001$, $\eta^2p = .10$, BF = 0.76, as larger than the low-fear participants. In order to examine whether both groups showed bias in size estimation, we compared the ratings of spiders and butterflies in each group. Results demonstrated that similar to Experiment 1, the high-fear group rated spiders as significantly larger than butterflies, $F(1, 62) = 6.63$, $p < .05$, $\eta^2p = 10$, BF = 1.82. In contrast, in the low-fear group there was no difference between the size ratings of spiders and butterflies, $F < 1$, *ns*, BF = 0.29. The results are illustrated in Fig. 4A.

In order to compare the influences of valence and relevance, we compared the size and unpleasantness ratings of spiders and wasps. Spiders were considered unpleasant in both groups, but were self-relevant only for the high-fear group. Wasps were considered unpleasant, but irrelevant for both groups. Participants in the high-fear group rated wasps as more unpleasant compared to participants in the low-fear group, $F(1, 62) = 71.13$, $p < .001$, $\eta^2p = .53$, BF = 95.69. Participants in both groups, however, rated the size of wasps similarly, $F < 1$, BF = 0.383. Thus, although wasps were rated as more unpleasant in the high-fear compared to the low-fear group, they were not perceived as larger by the high-fear group. These results imply that unpleasantness by itself is less likely to account for the bias in size estimation found in the high-fear group. In addition, these results suggest that bias in size estimation among highly fearful individuals is specific for a self-relevant stimulus and is not observed for other unpleasant stimuli.

The beetles in the experiment were used as control stimuli that bear some physical resemblance to spiders but are less unpleasant. Compared to the low-fear group, participants in the high-fear group rated beetles to be more unpleasant, $F(1, 62) = 18.24$, $p < .001$, $\eta^2p = .10$, BF = 309.3, and larger, $F(1, 62) = 7.21$, $p < .01$, $\eta^2p = .22$, BF = 4.96. Although we did not predict beetles to show a similar pattern of results to that of spiders, the verbal debriefing of participants at the end of the experiment may help explain this finding. Specifically, when we asked participants which pictures appeared in the task, most of them referred to the beetles as cockroaches. Thus, we believe that the beetles were self-relevant to the high-fear group, as it is known that there is a high comorbidity between phobia of spiders and phobia of cockroaches (Kendler, 1993).

3.3. The relationship between self-relevance, valence, and size estimation

Although wasps were rated as more unpleasant in the high-fear compared to the low-fear group, they were not perceived

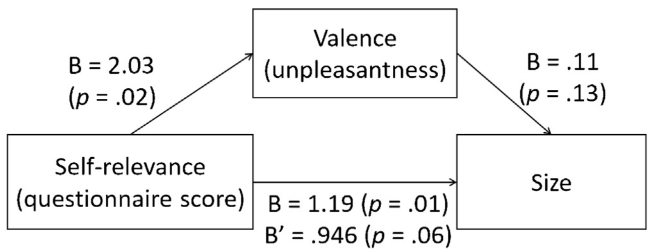

Fig. 5. Mediation model for the relationship between relevance, valance (unpleasantness) and spider size in the high-fear group. B = direct effect; B' = indirect effect.

as larger by the high-fear group. These results may suggest that unpleasantness by itself cannot account for bias in size estimation. However, this finding does not rule out the possibility that unpleasantness mediates the effect of relevance on size estimation. In order to test this suggestion, we used the data from both experiments, resulting in 89 participants; 50 in the high-fear group and 39 in the low-fear group. Specifically, we examined whether the link between self-relevance (assessed using the fear of spiders questionnaire score) and size estimation for the spider pictures was mediated by spider valence (unpleasantness rating). Before conducting the mediation analysis, we correlated these variables separately for the low-fear and the high-fear groups. In the low-fear group, unpleasantness was positively correlated with spider size (r = .47, p = .002). There were no other significant correlations. In the high-fear group we found a positive correlation between spider size and relevance (r = .34, p = .013), between spider size and unpleasantness (r = .3, p = .03), and between unpleasantness and relevance (r = .33, p = .019). Because both the correlation between unpleasantness and relevance and the correlation between unpleasantness and size were significant, we could use mediation analysis to test whether unpleasantness mediated the link between relevance and size estimation in the high-fear group. The mediation analysis was performed using the bootstrapping method with bias-corrected confidence estimates (Preacher & Hayes, 2008). The 95% confidence interval of the indirect effect was obtained with 5000 bootstrap resamples (Preacher & Hayes, 2008). Results of the mediation analysis revealed a mediating role for unpleasantness in the relation between relevance and size that was marginally significant (B' = .946, $t(48)$ = 1.96, p = .056). Importantly, the results also indicated a direct link between relevance and size when controlling for valence (B = 1.19; CI = .028–.67), suggesting that the correlation between self-relevance and size is only partially mediated by unpleasantness. Fig. 5 displays the results.

These findings suggest a role for valence in size estimation. In both groups, individuals who rated the spiders as more unpleasant also rated them as larger. However, among the high-fear group, the link between self-relevance and size estimation was also present when controlling for valence.

4. Discussion

In the current study, participants who were highly fearful of spiders and participants with low fear of spiders rated the size of spiders and other animals. The results of Experiment 1 demonstrated that although both groups rated the spider pictures as more unpleasant than the other pictures, only the highly fearful participants overestimated the size of spiders compared to butterflies. The results of Experiment 2 replicated these findings and indicated that a bias in size estimation among highly fearful individuals was specific to relevant stimuli (spiders and presumably beetles) and was not observed for non-relevant unpleasant stimuli (wasps). Mediation analysis conducted on the data of highly fearful participants in both experiments revealed that the relationship between self-relevance and size estimation was partially mediated by valence.

Our results comply with the notion that the relevance of a stimulus to the individual modulates the way it is perceived. In line with this notion, Purkis et al. (2011) found that both positive and negative self-relevant stimuli (e.g., spiders to individuals with fear of spiders; scenes from a TV series to its fans) were detected faster than stimuli that were not self-relevant. In addition, Witt, Linkenauger, Bakdash, and Proffitt (2008) found that golf players who excel in the game overestimate the size of the golf hole (a self-relevant stimulus). In the current study, the role for self-relevance in size perception was supported by two findings. First, although spiders were rated as more unpleasant than butterflies among the low-fear group, the size of spiders and butterflies was estimated to be similar in this group. This result implies that unpleasant stimuli are not associated with bias in size estimation in individuals who do not consider these stimuli as self-relevant. Second, although wasps were rated as more unpleasant than butterflies, the size of wasps was estimated to be smaller than the size of butterflies (in both the high- and low-fear groups).

Although these results may imply that stimulus valence does not play a role in size estimation, we did observe a positive correlation between unpleasantness and spider size, in both the low- and the high-fear groups. The correlation between unpleasantness and size among low-fear individuals fits earlier findings showing a valence effect on size estimationin healthy individuals (van Ulzen et al., 2008). Among highly fearful individuals, unpleasantness mediated the relationship between relevance and size. Nonetheless, this mediation was only partial since the link between relevance and size was marginally significant when controlling for valence. Therefore, while valence seems to have a role in size estimation, this role is not as robust as the role of self-relevance.

Findings of the current study may provide an important insight to the understanding of emotional processing. Emotional stimuli that have evolutionary value, such as spiders, are considered to be perceived automatically (unconsciously and uncontrollably; Öhman, Flykt, & Esteves, 2001). This notion is based on studies that showed attentional and perceptual biases for spiders compared to other (non-threatening) animals (e.g., New & German, 2015; Öhman et al., 2001). A recent study (New & German, 2015) employed an attentional-blink paradigm and found that people are more likely to detect spiders than modern threats (hypodermic needles) or non-threatening animals (houseflies). Accordingly, the authors suggested that humans are evolutionarily predisposed to perceive spiders as relevant stimuli. Our findings suggest that even if spiders were detected faster than other animals due to some (unknown) evolutionary mechanism, they would be associated with size-related distortions only when unpleasant or self-relevant to the individual.

Our results converge with previous findings demonstrating a positive correlation between size estimation and fear ratings among individuals who are afraid of spiders; Vasey et al. (2012) introduced a live spider to spider-phobic participants, covered it, and asked participants to estimate the physical size of the spider by drawing a line on an index card. In addition, participants had to estimate their fear level while seeing the spider. The authors found a correlation between reported fear-level and size estimation. The current study expands the findings of Vasey et al. (2012) in several ways. First, the inclusion of a control group (low-fear individuals) and additional (both unpleasant and neutral) animals enabled us to demonstrate that bias in size estimation occurs mostly among individuals who perceive spiders as self-relevant stimuli. Second, our results provide the first evidence for a bias in size estimation for the conceptual size (mental representation) of spiders. Third, the bias in size estimation of spiders observed in the current work was not modulated by short-term memory processes (as may be the case in the study presented in Vasey et al., 2012), but rather by the “prototype” size of a spider stored in long-term memory.

The current study has several limitations. First, our study cannot fully dissociate the effects of self-relevance and valence on size perception due to the correlation between these two constructs. The valence of self-relevant stimuli would usually be either positive or negative. Thus, valence should be taken into account when assessing the influence of self-relevance on cognitive and perceptual biases. Nonetheless, our findings reveal that valence and self-relevance are correlated only among individuals who perceive spiders as both highly relevant and highly aversive (high-fear group), but not among individuals who do not consider spiders as self-relevant (low-fear group). In addition, mediation analysis revealed that although valence plays a role in the association between self-relevance and size estimation, this association exists even when controlling for valence. Therefore, we believe that self-relevance plays a more crucial role in size estimation than valence does. A second limitation concerns the fact that our conclusions are limited to stimuli that are self-relevant and have a negative value for the observer. In line with previous data showing that self-relevant positive stimuli (e.g., the size of golf hole to golf players (Witt et al., 2008), and attention to characters from a loved TV show (Purkis et al., 2011) can result in perceptual and attentional biases, we believe that the degree to which a stimulus is self-relevant to an individual may affect size estimation to a larger extent than the emotional value of the stimulus. However, further research is needed before a firm conclusion can be made. Third, our sample size in Experiment 1 was rather small. However, the results of Experiment 1 were replicated in Experiment 2, which included a larger sample size. Nevertheless, some of our Bayes factors in the post-hoc analyses fell between 1.5 and 3, suggesting that even though the analyses were sensitive enough to accept the experimental hypothesis, collecting more evidence might strengthen our findings. We hope that by reporting the Bayes factor values, and not just *p*-values, the readers will be able to evaluate more critically the strength of our conclusions. Forth, our assessment of the unpleasantness of pictures cannot indicate whether the effects resulted from the levels of threat or the level of disgust associated with the pictures. This distinction may be especially interesting following our results of bias in size estimation for the beetle pictures. Most of the participants perceived the beetles as cockroaches, which are usually associated with a feeling of disgust (Tucker & Bond, 1997). Previous findings indicate that threat and disgust can affect distance perception differently (Cole, Balcetis, & Dunning, 2013), highlighting the importance of assessing the differences and commonalities of these two types of emotions. Additional research targeting the different emotions associated with perceptual biases for self-relevant stimuli may help to uncover the specific mechanism subserving these biases. In addition, it is important for further research to measure levels of arousal in addition to the specific emotions that the stimuli evoke, as well as levels of self-relevance of “control” stimuli. A fifth limitation concerns the inability of our study to estimate the magnitude of the size bias. Specifically, we do not have information regarding the actual size of the animals in reality. Each animal category included different species that had different sizes (e.g., the spider category included pictures of a brown house spider, which is relatively small (6–9 mm), but also pictures of a tarantula, which is relatively large (2.5–10 cm)). We were interested in the mental representation that participants had for these animals and thus asked participants to rate their *relative* size in comparison to small (fly) and large (lamb, bunny) animals. This design was very effective in detecting differences in size estimation between the low and the high-fear groups, but was unable to indicate whether spider-fearful individuals rated the spiders as larger than they actually are in real-life. It may be that low-fear individuals underestimated the size of the spiders compared to their actual size. Another possibility is that individuals with both low and high fear of spiders rated spiders as larger than they actually are, but this bias was more pronounced among the highly fearful individuals.

To summarize, the current work demonstrates that size distortion is modulated by the relevance of the stimulus to the observer, as well as its aversive value. Thus, to answer the question presented in the introduction, we suggest that both valence and self-relevance play a role in size perception.

Acknowledgments

We would like to thank our research assistants, Alexander Bulkin and Kana Luwisch-Liberman, for their help in collecting and analyzing data and providing helpful feedback. We would also like to thank Michael Ginzburg for his help in programing the VAS scale in E-PRIME, and Omer Linkovski, for his feedback on a previous version of this article. A special thanks to Dr. Efrat Gavish-Regev, for contributing her insights as an arachnology expert. Finally, we would like to thank Desiree Meloul for her help in English editing.

This work was supported by the European Research Council (ERC) under the European Union's Seventh Framework Programme (FP7/2007–2013)/ERC Grant Agreement 295644 to AH.

References

Aue, T., Guex, R., Chauvigné, L. A. S., & Okon-Singer, H. (2013). Varying expectancies and attention bias in phobic and non-phobic individuals. *Frontiers in Human Neuroscience*, *7*, 418. http://dx.doi.org/10.3389/fnhum.2013.00418

Aue, T., Hoeppli, M.-E., Piguet, C., Sterpenich, V., & Vuilleumier, P. (2013). Visual avoidance in phobia: particularities in neural activity, autonomic responding, and cognitive risk evaluations. *Frontiers in Human Neuroscience*, *7*, 194. http://dx.doi.org/10.3389/fnhum.2013.00194

Aue, T., & Okon-Singer, H. (2015). Expectancy biases in fear and anxiety and their link to biases in attention. *Clinical Psychology Review*, *42*, 83–95. http://dx.doi.org/10.1016/j.cpr.2015.08.005

Bar-Haim, Y., & Lamy, D. (2007). Threat-related attentional bias in anxious and nonanxious individuals: a meta-analytic study? *Psychological Bulletin*, *133*(1), 1–24.

Bruner, J. S., & Goodman, C. C. (1947). Value and need as organizing factors in perception? *The Journal of Abnormal and Social Psychology*, *42*(1), 33–44.

Bruner, J. S., & Postman, L. (1948). Symbolic value as an organizing factor in perception. *The Journal of Social Psychology*, *27*, 203–208.

Clerkin, E. M., Cody, M. W., Stefanucci, J. K., Proffitt, D. R., & Teachman, B. A. (2009). Imagery and fear influence height perception. *Journal of Anxiety Disorders*, *23*(3), 381–386. http://dx.doi.org/10.1016/j.janxdis.2008.12.002

Cole, S., Balcetis, E., & Dunning, D. (2013). Affective signals of threat increase perceived proximity. *Psychological Science*, *24*(1), 34–40. http://dx.doi.org/10.1177/0956797612446953

Davey, G. C. L., & Dixon, A. L. (1996). The expectancy bias model of selective associations: the relationship of judgments of CS dangerousness, CS-UCS similarity and prior fear to a priori and a posteriori covariation assessments. *Behaviour Research and Therapy*, *34*(3), 235–252. http://dx.doi.org/10.1016/0005-7967(96)88487-7

de Jong, P. J., & Muris, P. (2002). Spider phobia. *Journal of Anxiety Disorders*, *16*(1), 51–65. http://dx.doi.org/10.1016/S0887-6185(01)00089-5

Dienes, Z. (Ed.). (2008). In *Understanding psychology as a science* (1st ed.). Houndmills—Basingstoke, UK: Palgrave Macmillan.

Hester, R., Dixon, V., & Garavan, H. (2006). A consistent attentional bias for drug-related material in active cocaine users across word and picture versions of the emotional Stroop task. *Drug and Alcohol Dependence*, *81*(3), 251–257. http://dx.doi.org/10.1016/j.drugalcdep.2005.07.002

Jarosz, A. F., & Wiley, J. (2014). What are the odds? A practical guide to computing and reporting bayes factors. *The Journal of Problem Solving*, *7*(1), 2–9. http://dx.doi.org/10.7771/1932-6246.1167

Kendler, K. S. (1993). A longitudinal twin study of personality and major depression in women. *Archives of General Psychiatry*, *50*(11), 853–862. http://dx.doi.org/10.1001/archpsyc.1993.01820230023002

Klorman, R., Weerts, T. C., Hastings, J. E., Melamed, B. G., & Lang, P. J. (1974). Psychometric description of some specific-fear questionnaires. *Behavior Therapy*, *5*(3), 401–409. http://dx.doi.org/10.1016/S0005-7894(74)80008-0

Lang, P., Bradley, M., & Cuthbert, B. (2008). International affective picture system (IAPS): affective ratings of pictures and instruction manual. In *Technical report A-8*. Gainesville, FL: University of Florida.

Mogg, K., Field, M., & Bradley, B. P. (2005). Attentional and approach biases for smoking cues in smokers: an investigation of competing theoretical views of addiction. *Psychopharmacology*, *180*(2), 333–341. http://dx.doi.org/10.1007/s00213-005-2158-x

Mühlberger, A., Wiedemann, G., Herrmann, M. J., & Pauli, P. (2006). Phylo- and ontogenetic fears and the expectation of danger: differences between spider- and flight-phobic subjects in cognitive and physiological responses to disorder-specific stimuli. *Journal of Abnormal Psychology*, *115*(3), 580–589. http://dx.doi.org/10.1037/0021-843X.115.3.580

New, J. J., & German, T. C. (2015). Spiders at the cocktail party: an ancestral threat that surmounts inattentional blindness. *Evolution and Human Behavior*, *36*(3), 165–173. http://dx.doi.org/10.1016/j.evolhumbehav.2014.08.004

Öhman, A., Flykt, A., & Esteves, F. (2001). Emotion drives attention: detecting the snake in the grass. *Journal of Experimental Psychology: General*, *130*(3), 466–478.

Okon-Singer, H., Alyagon, U., Kofman, O., Tzelgov, J., & Henik, A. (2011). Fear-related pictures deteriorate the performance of university students with high fear of snakes or spiders. *Stress*, *14*(2), 185–193. Retrieved from http://informahealthcare.com/doi/abs/10.3109/10253890.2010.527401

Okon-Singer, H., Lichtenstein-Vidne, L., & Cohen, N. (2013). Dynamic modulation of emotional processing. *Biological Psychology*, *92*, 480–491.

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods*, *40*(3), 879–891. http://dx.doi.org/10.3758/BRM.40.3.879

Purkis, H. M., Lester, K. J., & Field, A. P. (2011). But what about the Empress of Racnoss? The allocation of attention to spiders and Doctor Who in a visual search task is predicted by fear and expertise. *Emotion*, *11*(6), 1484–1488.

Rachman, S., & Cuk, M. (1992). Fearful distortions. *Behaviour Research and Therapy*, *30*(6), 583–589. http://dx.doi.org/10.1016/0005-7967(92)90003-Y

Riskind, J. H., Moore, R., & Bowley, L. (1995). The looming of spiders: the fearful perceptual distortion of movement and menace. *Behaviour Research and Therapy*, *33*(2), 171–178. http://dx.doi.org/10.1016/0005-7967(94)E0023-C

Stefanucci, J. K., Gagnon, K. T., & Lessard, D. A. (2011). Follow your heart: emotion adaptively influences perception. *Social and Personality Psychology Compass*, *5*(6), 296–308. http://dx.doi.org/10.1111/j.1751-9004.2011.00352.x

Teachman, B. A., Stefanucci, J. K., Clerkin, E. M., Cody, M. W., & Proffitt, D. R. (2008). A new mode of fear expression: perceptual bias in height fear. *Emotion*, *8*(2), 296–301. http://dx.doi.org/10.1037/1528-3542.8.2.296

Teachman, B. A., & Woody, S. R. (2003). Automatic processing in spider phobia: implicit fear associations over the course of treatment. *Journal of Abnormal Psychology*, *112*(1), 100–109. http://dx.doi.org/10.1037/0021-843X.112.1.100

Tucker, M., & Bond, N. W. (1997). The roles of gender, sex role, and disgust in fear of animals. *Personality and Individual Differences*, *22*(1), 135–138. http://dx.doi.org/10.1016/S0191-8869(96)00168-7

van Ulzen, N. R., Semin, G. R., Oudejans, R. R. D., & Beek, P. J. (2008). Affective stimulus properties influence size perception and the Ebbinghaus illusion. *Psychological Research*, *72*(3), 304–310. http://dx.doi.org/10.1007/s00426-007-0114-6

Vasey, M. W., Vilensky, M. R., Heath, J. H., Harbaugh, C. N., Buffington, A. G., & Fazio, R. H. (2012). It was as big as my head, I swear! Biased spider size estimation in spider phobia. *Journal of Anxiety Disorders*, *26*(1), 20–24. http://dx.doi.org/10.1016/j.janxdis.2011.08.00

Wewers, M. E., & Lowe, N. K. (1990). A critical review of visual analogue scales in the measurement of clinical phenomena. *Research in Nursing & Health*, *13*(4), 227–236. http://dx.doi.org/10.1002/nur.4770130405

Whitehouse, A. M., Freeman, C. L., & Annandale, A. (1986). Body size estimation in bulimia. *The British Journal of Psychiatry*, *149*(1), 98–103. http://dx.doi.org/10.1192/bjp.149.1.98

Whitehouse, A. M., Freeman, C. P., & Annandale, A. (1988). Body size estimation in anorexia nervosa. *The British Journal of Psychiatry*, *153*(2), 23–26.

Wiers, R. W., Rinck, M., Dictus, M., & van den Wildenberg, E. (2009). Relatively strong automatic appetitive action-tendencies in male carriers of the OPRM1 G-allele. *Genes, Brain and Behavior*, *8*(1), 101–106. http://dx.doi.org/10.1111/j.1601-183X.2008.00454.x

Witt, J. K., Linkenauger, S. A., Bakdash, J. Z., & Proffitt, D. R. (2008). Putting to a bigger hole: golf performance relates to perceived size. *Psychonomic Bulletin & Review*, *15*(3), 581–585. http://dx.doi.org/10.3758/PBR.15.3.581